XVI. Sayh al Uhaymir 005 (ver. 2003)

Basalt, ~11 kg.
Apparent strew field (about 9 pieces)

Introduction

In November 1999, five macroscopically identical stores were recovered at two sites about 1800 meters apart in Oman, at a location called Sayh al Uhaymir. These were labeled SaU 005 and SaU 008 and have a combined weight of 9923 grams (Zipfel 2000). Additional pieces, labeled SaU 051 and SaU 094, were recovered by a Swiss expedition in January 2001 (Hofmann *et al.* 2001; Grossman and Zipfel 2001; Gnos *et al*. 2002) weighing 436 grams and 223 grams respectively, and the strewn field has been extended to 2.5 by 1.5 km. Two additional fragments SaU 060 (42 g) and SaU 090 (95 g) were reported by Russell *et al.* (2002).

SaU basaltic shergottites are very similar in mineralogy, texture, chemistry and exposure age to the DaG shergottites from Libya, but terrestrial weathering (caliche) appears to be much less pronounced (Zipfel 2000; Dreibus *et al*. 2000).

***Figure XVI-1**: Photograph of SaU 094 kindly provided by Edwin Gnos.*

Mineralogical Mode

	Zipfel (2000)	**Gnos *et al.* (2002)**
Pyroxene	48 vol. %	52 - 58
Olivine	25	22 - 31
Plagioclase	15	8.6 - 13
Opaques		~ 1
Sulfide		0.1 – 0.2
Phosphates		<<0.1
Melt Pockets		4.8 – 6.7

Two sides of SaU 094 (Gnos *et al*. 2002) are coated with very thin black fusion crust (figure XVI-1).

Petrography

SaU 005 has a porphyritic texture of large olivine phenocrysts set in a fine-grained groundmass of low Ca pyroxene and maskelynite (Zipfel 2000). Olivines showing mosaicism and planer features, severely fractured pyroxenes and maskelynitized feldpar indicate that this meteorite was highly shocked. Veins and pockets of "vesicular shock melt" were found to be abundant (~9 %!), with vesicles up to 3 mm in size.

Goodrich and Zipfel (2001a, b) have studied the melt inclusions in chromite and olivine. The glass in these inclusions is high Si = 70-74%.

Gnos *et al.* (2002) have studied the shock melt patches in SaU 094 and conclude that the shock pressure was locally as high as 80 GPa. Minute oblate vesicles are common in the glassy and recrystallized shock melts and have a preferred orientation.

Caliche from SaU 008 has been studied by Schwenzer *et al*. (2002).

Mineral Chemistry

Olivine: Large olivine phenocrysts (2 mm) are normal zoned from Fo_{71} to Fo_{65}. Olivines in groundmass are ~Fo_{65}.

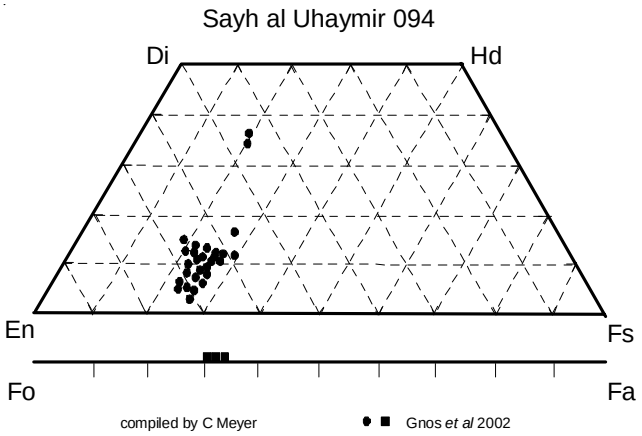

Figure XVI-2*: Composition diagram for pyroxene and olivine from SaU 094 (data replotted from Gnos et al. 2002).*

Pyroxene: Pigeonite is $En_{70}Wo_6$ to $En_{61}Wo_{13}$ and augite is $En_{50}Wo_{32}$ (figure XVI-2). There is no orthopyroxene.

Feldspar: Maskelynite is $An_{51\text{-}65}$ $Or_{0.3\text{-}0.9}$ and relatively homogeneous.

Oxides: Gnos *et al.* (2002) have reported detailed analyses of chromite, ulvöspinel and ilmenite.

Phosphate: Merrillite $Ca_9Na(Mg,Fe)(PO_4)_7$ contains considerable F and trace Cl.

Sulfides: Detailed analyses of sulfides are given in Gnos *et al.* (2002) who report a non-magnetic pyrrhotite $Fe_{10}S_{11}$ and some pentlandtite exsolution.

Glass: Boctor *et al.* (2001) have determined the chemical composition of the shock melt glass as MgO=23.8-34.6%, FeO=16.4-24.7%, CaO=2.1-10.6%, SiO_2=46.6-51.6%, Al_2O_3=1.3-1.8% and have reported the D/H ratio. Gnos *et al.* (2002) have also analyzed shock glass in this rock.

Whole-rock Composition

Dreibus *et al.* (2000) report that the chemical composition of SaU 005 (Table XVI-1) is similar to that of DaG 476 (figure XVI-3). The Ga/Al ratio is 4.4 x 10^{-4}. Gnos *et al.* (2002) determined the composition of the fusion crust.

Cosmogenic Isotopes and Exposure Ages

Pätsch *et al.* (2000) report an exposure age of 1.5 ± 0.3 Ma from $^{22}Ne/^{21}Ne$ measurements (similar to that of DaG476). Pätsch *et al.* also report a high ^{26}Al (37.4

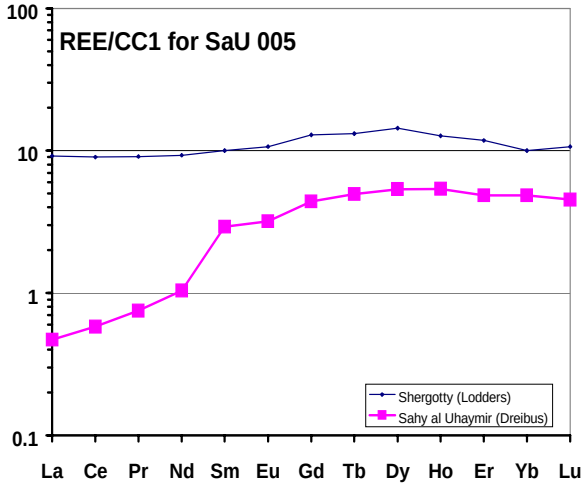

Figure XVI-3*: Normalized rare earth element diagram for SaU 005 (Dreibus et al. 2000) compared with that of Shergotty (Lodders 2000).*

dpm/kg), but low compared to the calculated saturation value. Park *et al.* (2001) report a ^{21}Ne exposure age of 0.7 Ma.

Other Isotopes

Hoffman *et al.* (2001) and Gnos *et al.* (2002) reported $\Delta^{17}O$ = +0.28 per mil (which is thought to be low because of terrestrial contamination). Mohapatra and Ott (2000) and Mohapatra *et al.* (2001) have found that high temperature fraction of the ^{15}N, ^{129}Xe and Kr/Xe ratio in gas released from the "shock melt glass" are representative of the Martian atmosphere. Schwenzer *et al.* (2002) have studied the nitrogen and noble gases in caliche from SaU 008. Nishiizumi *et al.* (2001) report preliminary analyses of ^{10}Be, ^{26}Al, ^{36}Cl and ^{21}Ne and find similarity with Dar al Gani 476.

Terrestrial Weathering

Calcite veinlets are common at the surface of the SaU 094 and patches of Fe hydroxide occur as fillings of cracks and as small pockets of finely layered oxidation products of mixed phases. However, pyrrhotite usually shows no sign of oxidation (but see detailed discussion in Gnos *et al.* (2002).

Extra-terrestrial Weathering

Hoffman *et al.* (2001) mentioned probable "shocked Fe-carbonate", but this has not been confirmed.

Processing

X-ray tomograms of SaU 094 were made before slicing the sample – see Gnos *et al.* (2002).

Table XVI-1: Composition of Sayh al Uhaymir.

reference	Dreibus 2000		Dreibus 2000		Gnos 2002	
weight	5.4 grams!				fusion crust	
SiO2 %	47.2	(a)			48.49	(e)
TiO2	0.42	(a)			0.41	(e)
Al2O3	4.53	(a)			4.97	(e)
FeO	18.34	(a)	17.8	(b)	16.34	(e)
MnO	0.46	(a)	0.45	(b)	0.43	(e)
CaO	5.74	(a)	5.18	(b)	5.62	(e)
MgO	20.49	(a)			20.54	(e)
Na2O			0.6	(b)	0.64	(e)
K2O			0.022	(b)		
P2O5	0.31	(a)				
sum						
Li ppm						
C %	0.11	(c)				
F			56	(b)		
S %	0.16	(c)			tr.	
Cl			143	(b)		
Sc			29.9	(b)		
V	136	(a)				
Cr					tr.	
Co			55	(b)		
Ni			310	(b)		
Cu						
Zn			61	(b)		
Ga			8.8	(b)		
Ge						
As			0.46	(b)		
Se						
Br			0.28	(b)		
Rb						
Sr						
Y						
Zr						
Nb						
I ppm			1.9	(b)		
Cs ppm						
Ba						
La	0.11	(d)	0.1	(b)		
Ce	0.35	(d)	<.6	(b)		
Pr	0.067	(d)				
Nd	0.47	(d)	<.65	(b)		
Sm	0.43	(d)	0.42	(b)		
Eu	0.18	(d)	0.2	(b)		
Gd	0.86	(d)				
Tb	0.18	(d)	0.19	(b)		
Dy	1.3	(d)	1.42	(b)		
Ho	0.3	(d)	0.3	(b)		
Er	0.77	(d)				
Tm						
Yb	0.79	(d)	0.81	(b)		
Lu	0.11	(d)	0.13	(b)		
Hf	0.43	(d)	0.39	(b)		
Ta						
Th ppm	0.012	(d)	<.1	(b)		
U ppm	0.05	(d)	0.05	(b)		

technique (a) XRF, (b) INAA, (c) CSA, (d) MIC-SSMS, (e) electron probe